WHAT IS CLAIMED IS:

1. A vibration suppression apparatus for a hybrid vehicle, comprising:

a main power source;

a plurality of auxiliary power sources;

a planetary gear mechanism to modify a gear ratio when an output of the main power source is transmitted to a drive output member; and

a vibration suppression control section that selects two power sources whose torque controls are enabled to be performed and superposes a vibration suppression control signal onto each of torque commands supplied to the selected two power sources to suppress two-degrees-of-freedom vibrations of the planetary gear mechanism.

2. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 1, wherein the planetary gear mechanism is set to be an actual plant and a dynamic model on the vibrations of the planetary gear mechanism is set to be a plant model and the vibration suppression control section inversely calculates an external disturbance torque that causes the vibrations to be developed in the planetary gear mechanism using an inverse model of the plant model and additively supplies correction torques which cancel at least a part of the two-degrees-of-freedom vibrations of the actual plant to two power sources from among the power sources coupled to the respective elements of the actual plant.

3. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 2, wherein the vibration suppression apparatus further comprises a displacement measurement section that measures displacements of the respective elements of the actual plant developed according to torques acted upon the respective elements of the actual plant and the vibration suppression control section comprises: an actual displacement calculating section that calculates actual displacements of the respective elements using the torques acted upon the respective elements of the actual plant and displacement measurement values of the displacement measurement section; a model displacement calculating section that calculates displacements of the plant model using the torques acted upon the respective elements and using the plant model; a vibration displacement calculating section that calculates an error between each of the actual displacements of the actual plant and the corresponding one of the displacements of the plant model; a disturbance torque calculating section that inversely calculates the external disturbance torques using the calculated error and an inverse model of the plant model; a correction torque calculating section that calculates a correction torque whose sign is inverted to the calculated disturbance torque; and a correction torque adding section that additively supplies the calculated correction torque to each of the two power sources to each of which the corresponding one of the selected two elements is coupled.

4. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 1, wherein the vibration suppression apparatus further comprises a displacement measurement section that measures the displacements of the respective elements developed according to torques acted upon respective elements of the actual plant and the vibration suppression control section comprises: an actual displacement calculating section that calculates actual displacements of the actual plant using torques acted upon the respective elements of the actual plant and displacement measurement values of the displacement measurement section; a damping torque calculating section that calculates damping torques using the calculated actual displacements and an electrical damper; a correction torque calculating section that calculates correction torques, each of their signs being inverted to that of the corresponding one of the calculated damping torques; and a correction torque adding section that additively supplies each of the calculated correction torques to the corresponding one of the power sources to which the selected two elements are respectively coupled.

5. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 1, wherein the vibration suppression apparatus further comprises: a displacement measuring section that measures displacements of the respective elements of the actual plant developed according to torques acted upon the respective elements of the actual plant and the vibration suppression control section comprises: an actual displacement calculating section that

calculates actual displacements of the respective elements using the torques acted upon the respective elements of the actual plant and the displacement measurement values; a model displacement calculating section that calculates model displacements using the torques acted upon the respective elements and a plant model; a vibration displacement calculating section that calculates an error between each the actual displacements of the actual plant and the corresponding one of the model displacements of the plant model; a damping toque calculating section that calculates damping torques using the calculated errors and an electrical damper; a correction torque calculating section that calculates correction torques, each of their signs being inverted to that of the calculated damping torque; and a correction torque adding section that additively supplies the calculated correction torque to the selected two power sources to each of which the corresponding one of the elements of the planetary gear mechanism is coupled.

6. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 1, wherein the vibration suppression control section selects the two power sources, each selected power source being superior in a torque control response from among the power sources whose torque controls are enabled to be performed, superposes the vibration suppression control signal onto each of the torque commands supplied to the selected two power sources to suppress the two-degree-of-freedom vibrations of the planetary gear mechanism.

7. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 1, wherein the vibration suppression control section selects the two power sources to which coupling axles having two higher frequencies from among resonance frequencies of a torsional system coupling the respective elements of the planetary gear mechanism to the respectively corresponding power sources and superposes the vibration suppression control signal onto each of the torque commands supplied to the selected two power sources to suppress the two-degrees-of-freedom vibrations of the planetary gear mechanism.

8. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 1, wherein the main power source is an engine, the plurality of auxiliary power sources are two motors, and the planetary gear mechanism to modify the gear ratio when the output of the main power source is transmitted to the drive output member is a four-element, two-degrees-of-freedom planetary gear mechanism expressed in a lever diagram in which the engine and the drive output member are interposed between the two motors and the vibration suppression control section superposes the vibration suppression signal onto each of the torque commands supplied to the two motors disposed on both ends of the lever diagram.

9. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 8, wherein the main power source is an engine, the plurality of auxiliary power sources are a coaxial multi-layer motor having one

stator and two rotors, and the planetary gear mechanism to modify the gear ratio when the output of the main power source of the engine is transmitted to the drive output member is a Ravigneaux compound planetary gear train expressed in the lever diagram in which the engine and drive output member are interposed between the two motors constituting the coaxial multi-layer motor.

10. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 3, wherein the actual displacement calculating section calculates a translation displacement and a rotation displacement of the actual plant as follows:

$$\begin{bmatrix} translation \quad displacement \\ rotation \quad displacement \end{bmatrix} = \begin{bmatrix} 1 & a \\ 1 & -b \end{bmatrix}^{-1} \begin{bmatrix} x1 \\ x2 \end{bmatrix},$$ wherein x1 and x2 denote the actual translation of the selected one and other of the two elements to each of which the corresponding one of the selected respective two power sources is coupled and a and b denote torque arms between a weight center of a lever diagram of the planetary gear mechanism and that of each of the selected two elements, the model displacement calculating section calculates a translation displacement of the plant model and a rotation displacement thereof using a translation torque total for the respective elements of the plant model and a rotation torque total thereof for the elements of the plant model and translation inertia (M) and rotation inertia (J) of the planetary gear mechanism, the vibration displacement calculating section calculates the errors between the actual translation displacement of the actual

plant and the model translation displacement of the model plant and between the actual rotation displacement of the actual plant and the model rotation displacement of the plant model, the disturbance torque calculating section inversely calculates their respectively corresponding translation disturbance torques using the respective errors and the inverse model of the plant model, and the correction torque calculating section synthesizes damping torques for the two elements to which the selected two power sources are coupled as follows:

$$\begin{bmatrix} damping & torque & 1 \\ damping & torque & 2 \end{bmatrix} =$$

$$\begin{bmatrix} 1 & p \\ 1 & -q \end{bmatrix}^{-1} \begin{bmatrix} translation & torque \\ rotation & torque \end{bmatrix},$$

wherein damping torques 1 and 2 denote correction torques 1 and 2 to be superposed on the respective torque commands 1 and 2 to be supplied to the respective two elements to each of which the corresponding one of the selected two power sources is coupled, p and q denote torque arms of the two elements for the selected two power sources in the lever diagram of the planetary gear mechanism, and translation and rotation torques denote translation and rotation disturbance torques.

11. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 10, wherein the vibration suppression control section further comprises a filtering section that filters the translation disturbance torque and the rotation disturbance torque calculated by the disturbance torque calculating section and outputs the filtered

translation and rotation disturbance torques to the correction torque calculating section.

12. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 10, wherein the main power source is an engine, the plurality of auxiliary power sources are first and second motors (MG1 and MG2) couples to the selected two elements (S1 and S4), and the planetary gear mechanism to modify the gear ratio when an output of the engine is transmitted to the drive output member is a four-element, two-degrees-of-freedom planetary gear mechanism expressed in a lever diagram in which the engine and the drive output member are interposed between the two motors and the vibration suppression control section superposes the vibration suppression control signal onto each of the torque commands supplied to the two motors disposed on both ends of the lever diagram.

13. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 12, wherein the translation torque total is expressed as T1 + T2 - TL3 + T4, wherein T1 denotes a torque acted upon the first element of the four-element, two-degrees-of-freedom planetary gear mechanism, T2 denotes a torque acted upon the second element thereof, TL3 denotes a load torque acted upon a third element of the drive output member thereof, T4 denotes a torque acted upon a fourth element thereof and the rotation torque total is expressed as T1Acg + T2(Acg -a2) - TL3(Acg - a3) + T4 (Acg -a4), wherein Acg denotes a position of the weight center of the planetary gear mechanism

from a weight center position of the first element and expressed as (a2J2 + a3J3 + a4J4)/M wherein J2, J3, and J4 denote rotation inertia of the second, third, and fourth elements of the four-element, two-degrees-of-freedom planetary gear mechanism and M denotes a translation inertia of four-element, two-degrees-of-freedom planetary gear mechanism, torque arms of a2, a3, and a4 from the weight center of the first element are dimensionless values determined according to the gear ratio of the four-element, two-degrees-of-freedom planetary gear mechanism.

14. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 13, wherein M = J1 + J2 J3 + J4 and J = $J1Acg^2 + J2(Acg - a2)^2 + J3(Acg - a3)^2 + J4(Acg - a4)^2$, wherein J1 denotes the rotation inertia of the first element of the four-element, two-degrees-of-freedom planetary gear mechanism.

15. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 14, wherein the translation displacement of the plant model and the rotation displacement are expressed as follows; translation displacement = double integrals of the translation torque total/M with respect to time and rotation displacement = double integrals of the rotation torque total with respect to time.

16. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 15, wherein the inverse model of the plant model is expressed as Ms^2 and Js^2

wherein **s** denotes a Laplace transform operator.

17. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 10, wherein the damping torque calculating section calculates the damping translation torque and the damping rotation torque, respectively, using the errors and the electrical damper having transfer functions of $C_M\mathbf{s}$ for the error between the translation displacements of the actual plant and the plant model and of $C_J\mathbf{s}$ for the error between the rotation displacements of the actual plant and the plant model.

18. A vibration suppression apparatus for a hybrid vehicle as claimed in claim 13, wherein $M = J1 + Jm1 + J2 + J3 + J4 + Jm4$ and $J = (J1+ Jm1)Acg^2 + J2(Acg - a2)^2 + J3(Acg - a3)^2 + (J4+ Jm4)(Acg - a4)^2$, wherein J1, J2, J3, and J4 denote the rotation inertias of the first, second, third, and fourth elements of the four-element, two-degrees-of-freedom planetary gear mechanism and Jm1 denote a rotation inertia of the first motor (MG1) coupled to the first element of the four-element, two degrees-of-freedom planetary gear mechanism and Jm4 denotes a rotation inertia of the second motor (MG2) coupled to the fourth element of the two-degrees-of-freedom planetary gear mechanism.

19. A vibration suppression apparatus for a hybrid vehicle, comprising:

main power source means;

auxiliary power source means;

planetary gear mechanism means for modifying a gear ratio when an output of the main power source means is transmitted to a drive output member; and

vibration suppression controlling means for selecting two power sources whose torque controls are enabled to be performed and for superposing a vibration suppression control signal onto each of torque commands supplied to the two power sources to suppress two-degrees-of-freedom vibrations of the planetary gear mechanism.

20. A vibration suppression method for a hybrid vehicle, the hybrid vehicle comprising:

a main power source;

a plurality of auxiliary power sources; and

a planetary gear mechanism to modify a gear ratio when an output of the main power source is transmitted to a drive output member and the vibration suppression method comprising:

selecting two power sources whose torque controls are enabled to be performed; and

superposing a vibration suppression control signal onto each of torque commands supplied to the selected two power sources to suppress two-degrees-of-freedom vibrations of the planetary gear mechanism.